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Griglietta, C

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ELECTRO-MAGNETISM.

A

BRIEF ESSAY OR INFORMAL LECTURE

ON

ELECTRO-MAGNETISM,

WITH

A FULL DESCRIPTION OF MODELS

OF

DAVENPORT'S MACHINES,

AS NOW

EXHIBITED IN NEW YORK; AND AT THE MASONIC
HALL, PHILADELPHIA:

WITH AN

EXTRACT FROM THE AMERICAN JOURNAL OF SCIENCE,

BY

PROFESSOR SILLIMAN.

cu d

ALSO,

OTHER INTERESTING MATTER ON THIS SUBJECT.

COMPILED

BY C. GRIGLIETTA, ESQ.

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INTRODUCTION.

THE following pages have been compiled to suit the capacity of all, and to enable those persons who have had no previous knowledge of Electricity, Galvanism, Magnetism, or Electro-Magnetism, by perusing these pages, to understand at once the power employed to propel and give rotary motion to Davenport's Electro-Magnetic Machines. It has no pretensions to be a scientific work, and doubtless those who have a thorough knowledge of the subjects here treated of, will discover numerous errors. But the compiler has only to observe, that having had charge of some of these Machines, and having explained them to some hundreds of different capacities, he has been induced, at the request of several friends, to throw together something that he hopes will enable every one who has had an opportunity of witnessing the Electro-Magnetic Machinery, to understand the whole moving principle; and by those who have not seen, or who have no knowledge of these Machines, or the principles by which they are operated or set in motion, he flatters himself that the subject will be better understood by this unpretending and simple explanation, than a more elaborate or scientific description could possibly accomplish.

The compiler is principally indebted to Mr. R. Cook, one of the proprietors of this invention, it being mostly the substance of his remarks when explaining the principles of Davenport's Machinery.

C. G.

January, 1838.

DESCRIPTION OF DAVENPORT'S MACHINERY.

It is not intended in this brief sketch to treat either of Electricity, or Magnetism, further than is absolutely necessary to give the reader a thorough knowledge of the manner in which the motive power acts on this machinery. Avoiding speculation, we shall point only to fact; and pursuing the rigid path of proof, demonstrate at every step the unerring principles which in these machines govern the production of power, and clearly show that it can be augmented to an unlimited extent.

The term magnetism expresses the peculiar properties which iron and some of its compounds, as well as nickel and cobalt, may be made to possess; these are four.—1. Polarity.—2. Attraction of *unmagnetised* iron.—3. Attraction and *repulsion* of *magnetised* iron.—4. The power of *inducing magnetism* in other iron.

Steel, when magnetised, retains its magnetic qualities. Iron does not. Steel cannot be rendered a *temporary*, nor iron a *permanent* magnet.

Polarity.

The ends of all magnets are termed poles—the two ends are dissimilar poles. If one end be south, the other must be north, and vice versa. Both poles will attract iron with equal force. Neither pole will *attract*, whilst on the contrary, either pole will repel a similar pole of a previously magnetised body. Thus the north and south poles must invariably attract each other, whilst the north as invariably repels a north, and the south a south pole. To this unalterable law of magnetics the reader must give particular attention. “Dissimilar poles (north and south), attract, and similar poles (two north or

two south), repel each other." On these governing principles, and on the mode of changing the polarity of the Electro-Magnet, the discovery of which is due (we believe), to Davenport, depends the motion of the machinery.

Attraction of Unmagnetised Iron.

Both poles are equally efficient in attracting unmagnetised iron, and no repulsion exists between either pole of a magnet and unmagnetised iron.

Attraction and Repulsion of Magnetised Iron.

The motion of the machinery is altogether dependant on change of polarity and this property of the magnet; and without the presence of these opposite powers, the rotary motion would be nugatory for any useful purpose. The following experiment best illustrates these qualities—suspend a magnetised steel needle; freely oppose to the north pole thereof, the south pole of a magnet held in the hand, the poles (north and south) immediately attract each other. Reverse the poles, opposing a north to the north pole, and they immediately repel each other. By alternating the poles, i. e. attracting one and repelling the other, the manner in which the magnetic power acts on the machinery, and causes its rotation, will be palpable.

The Power of Inducting Magnetism into other Iron.

If a piece of loadstone (natural magnet), or magnetised steel (permanent magnet), be placed in contact with a piece of soft iron, the iron becomes immediately a magnet by induction, having (whilst in contact only), all the properties of magnetism; and to this susceptibility of iron is owing the facility, by means of the galvanic fluid, of perfecting the Electro-Magnet.—A further law of magnetic induction is, that it induces iron (at the point of contact), with a dissimilar polarity; thus the south pole of a magnet renders iron in contact a north pole, and vice versa. Every magnetic body must possess two poles, one south, the other north.

The Electro-Magnet.

The Electro-Magnet, as its name implies, means a magnet by electricity. The first discoverer of the magnetic properties of electric currents was Professor Oersted, of Copenhagen;—this was in 1819. He went no further, however, than to produce deviations in the magnetic needle, by passing the galvanic fluid near it. This discovery aroused the attention of the scientific world to the subject. Many experiments were tried, and new discoveries made. Professor Moll, of Utrecht, by winding a piece of soft iron with copper wire, and making the wire a part of the galvanic circle, produced the Electro-Magnet. In 1830, Professor Henry, of Albany, made an improvement in the manner of winding the wire, and made an Electro-Magnet which suspended a weight of more than two tons. Many more powerful ones have since been made.

To render a bar of iron an Electro-Magnet, it is necessary to insulate it, with the exception of the extremities, or poles, with silk, coated with a thin adhesive varnish; it must then be further insulated by a continuous copper wire, wound spirally, and closely, at right angles to the iron, leaving as before the two ends or poles bare, and sufficient of each end of the wire to act as conductors to the galvanic fluid, which must be compelled to follow the convolutions of the wire around the iron; for should the wire not be covered with cotton, and the fluid pass from one convolution to the other, moving parallel to the iron, no magnetism is produced. The iron must be wrapped with silk, and by a continuous current of electricity it renders it magnetic; and also to communicate to the Electro-Magnet all the properties of magnetism, which it does in a more powerful degree than the permanent magnet can be made to possess. On the galvanic electricity being withdrawn, it instantly loses its magnetic powers. Another and most important peculiarity of the Electro-Magnet is, its capability of changing polarity at the pleasure of the operator; this is effected by passing the positive conductor, or the wire leading from the copper plate of the battery, on a different end of the magnet, and thereby compelling the galvanic current to flow through the wire at opposite points.

By this simple and ready means, any number of magnets, in systematic connexion, can be made to change polarity at pleasure; and any position of polarity can be obtained by observing the rule that winding the wire west to east, *first ascending*, and connecting it with the positive wire, will be a south pole; and west to east, *first descending*, a north pole.

The Battery.

The battery is composed of alternate plates of copper and zinc. Nearly all the metals will answer the purpose, but in regard to energy and economy, copper and zinc are found the best. It is not necessary that it should be made in any particular form; any form that is found most convenient may be adopted, as it is merely necessary that the two metals should alternate, copper, zinc, copper, zinc, and so on, according to the power required. The different plates of zinc are all connected by a metallic strap; so are the several plates of copper connected in like manner by a metallic strap, and thus form only one pair of plates; this arrangement gives no electric shock, and no danger can arise from such a battery. When the battery is in any bath that acts chemically on the zinc, the galvanic fluid is evolved. The copper is not acted upon in a sensible degree. As the galvanic or electric fluid is produced by the chemical action on the zinc, it is received from the bath by the several plates of copper (copper being among the best conductors of electricity), and is passed from the battery on the wire attached to the plates of copper. When the circle is closed, that is, when the two wires (that attached to the copper and the other to the zinc), are connected by a conductor of electricity to the magnets in the machinery, the fluid returns to the battery on the wire attached to the zinc. The wire attached to the copper side of the battery is termed the positive, and that to the zinc is termed the negative. The positive electricity passes from the copper battery, and following its conductor into the wire wound around the magnets of the machine, returns again to the battery on the wire attached to the zinc, where it was first generated, moving continually in a circle, and rendering in its progress all the iron in connexion magnetic; for, to pro-

duce a Galvanic or Electro-Magnet, it is only requisite to pass the fluid *around* iron, which has been wound with copper, and insulated as previously described.

As a bath for the battery, common pump water will produce galvanic action, and could be made to run these machines. If the water be acidulated, a more rapid action will be produced, so that citric acid, sea water, solutions of the mineral salts, vinegar, &c., will answer the purpose. The bath which we generally use is sulphate of copper dissolved in water. The solution is a very weak acid, and may be kept up any length of time by a slight addition of sulphate of copper (blue vitriol.)

The Machine.

The manner of making the Electro-Magnet and its powers, as in contradistinction to the steel or permanent magnet, have been already enumerated, and it is here merely requisite to remark, that all the magnets used in the machinery are Electro-Magnets. In giving a description of a machine, it will be very difficult, if not almost impossible to convey to the reader, without ocular demonstration, such a description as will enable him to comprehend its combined action. It must be seen, despite the clearest and most minute description that can be conveyed, to be thoroughly understood. Not that it *is* complicated. On the contrary, its extreme simplicity is its great recommendation, and it is this very simplicity as to parts, which renders it so difficult to convey to any one (who has not seen the machine at work), a true idea of the action of the whole.

The terms positive and negative are used only with reference to the different or opposite state of electricity, in which the conducting wires from the battery always are when the battery is immersed. In speaking of magnets, they are distinguished as north or south poles; for as both poles attract and lift unmagnetised iron with equal power, neither are negative or wanting in magnetism. Besides, a positive or negative state of electricity, acting on the end of the magnet, does not determine its polarity. It is the manner of winding the copper wire which determines that, as before stated.

The machine now to be described is of two magnetised pieces only, being the fewest number of parts, and most simple apparatus by which the rotary motion can be obtained; a small bar of iron wound as an Electro-Magnet, being in form three sides of an oblong, is fixed vertically on a platform; a shaft revolves in a step, working through a centre aperture in the horizontal part of the oblong bar; the rotary magnet, a bar of iron, is pierced through at its centre by the shaft and fixed to it; the ends of the wire with which the revolving magnet is wound, are soldered to a small circular disc or ferrule of silver, which is divided into two equal parts, and through which passes the revolving shaft, and to which it is also made fast; the interior of the disc is of wood. On to each half of the disc is brought in close contact two wires from the battery, one from the copper, the other from the zinc. Thus, one half of the disc will be in a positive state of electricity, and the other half negative. As the disc revolves, it follows that the galvanic fluid must pass alternately on to each end of the magnet, which, being differently wound from the other, as before remarked, changes, and determines its polarity. Bearing in mind the form of the machine, its action may be conceived thus—suppose the right hand stationary shaft to be magnetised a north pole, the other end of the same will be a south pole. The ends of the rotary magnets, if at right angles to the stationary ones, will have their polarity thus—that opposite the stationary north, will be a south, and its other end a north. In this position the machine will not act, because all the magnets are *attracting* each other—but place the rotary magnet, so that the polarity is changed, and the action will immediately commence; because the rotary magnet being changed to a north pole, is *repelled* by the north stationary magnet, and the south by the south stationary magnet, and this repulsive action continues, until the magnets are brought within the power of the attraction of their dissimilar poles, which complete the rotary circle, and will continue so long as the battery is attached.

Having endeavoured to give the reader such an idea of a machine, constructed on the simplest scale, as we hope may be comprehended by any capacity, we shall not contemplate the

description of a more complicated machine, or one which has more than two changes of poles, because we feel it impossible to do so in such a manner as would be generally intelligible. Such a machine must be seen, to be understood; but we anticipate the foregoing delineation will greatly assist, in giving those who may hereafter view any Electro-Magnetic machine, a clear conception of its working and operation.* It must be always borne in mind, that these machines are moved entirely by magnetic attraction and repulsion; for it is a very general impression, before seeing them, that they owe their power to electric force and velocity;—such is not the case. A galvanic current so feeble as not to be felt even on the tongue, will give a magnetic power capable of suspending an immense weight; for the galvanic fluid is multiplied in power many millions of times, when thus converted to induct magnetism into Electro-Magnets.

However great the interest and curiosity excited by this machine, in a scientific and philosophic point of view, as illustrating the wonderful operations of electricity and magnetism on our earth, and as an all pervading principle of the Universe, inquirers in general are more desirous to be satisfied of its utility as a motive power—of its capability and extent of augmentation—facility of operation and comparative economy.

The magnetic currents may be compared to a stream of water, acting similarly to its force on a water wheel. We shall give an illustration describing the course or direction of the magnetic currents. Place two semi-circular steel magnets, with their adhering poles opposite to each other, about an inch asunder. On covering them with paper, and sprinkling thereon lightly, iron filings, the filings will arrange themselves in curves; now place the repelling poles opposite each other, and the filings will move directly across the circle. The machinery depends entirely on the force and direction of these currents, and as they always move between the opposite poles, that is,

* It may be here remarked, however, that any number of changes of polarity can be effected in making an Electro-Magnetic machine. A machine is now nearly completed, for the purpose of driving a printing-press, with twenty-six changes of polarity to each revolution of the motive-wheel.

between the north and south poles, it follows that they will move around a circle in angles, corresponding in number with the number of magnetic poles in the centre. If, therefore, we have four poles in the circle, the magnetic currents will move in a square—if we have eight poles, they will move in an octagon, and so on; when there are fifty or a hundred poles in the circle, the magnetic currents move around, within the circle, in the direction of the revolving magnets, and thus we bring into use all the magnetic power generated; hence we infer, from repeated experiments, that the power of these machines increases in a greater ratio than they are increased in size. Around a motive-wheel, eleven feet in diameter, we can place fifty or more magnets in a row, with their poles projecting at the periphery. Now, no one can deny, that the first magnet placed upon the wheel, possesses, and will exert some power in giving motion to the machine; the second magnet will double that power; the third will treble it; and the fiftieth will make it fifty-fold.

We then place another row around the wheel, which doubles the aggregate power of the first row, then another, and so continue adding rows of magnets, until the amount of power desired is obtained—the power being always proportioned to the number and size of the magnets in use. The calculation is as certain, and as strictly mathematical, as that of the steam engine.

It is an every day remark, that many machines work well on a small scale, that will not do so on a large one. If this be true, of a mere machine, it is never true of the power that propels the machine. A machine, and the power that moves it, should always be kept separate in the mind. Water will work on any desirable scale; so will steam; so will animals; and so, too, will magnets. A power will always work on any scale on which it can be procured. And unless we are limited in the number of magnets to be manufactured, we cannot be limited in the power that may be obtained from them.

Durability and simplicity of construction, always so desirable, and often absolutely necessary in machinery, is possessed by these machines in a degree far beyond that of the steam en-

gine. The magnets, which are ninety per cent. of its cost, are not subject to any friction, and are, it may be almost said, indestructible, whilst the remaining ten per cent. of its cost may be kept in repair for a less sum than would suffice to supply a steam engine with oil. The wear and tear of line shafts is unnecessary; each lathe or spindle in a factory can be supplied with the exact amount of power it requires, independently of any other. Each workman, when he has a job of work to do, can commence it *on the instant*; when he has finished it, he suspends his battery, and the machine is at rest, (always ready, however, *at the instant*, to commence again,) and when not employed costing nothing. Such is not the case with the steam engine; many of them are now rusting and going to decay, because they have not constant employment, and to raise steam for short jobs would be too expensive.*

Its safety is a paramount consideration. The benefit society derives from the steam engine, is daily marred by the most heart rending and appalling accidents and destruction of human life and happiness. It may be said, that this is in part owing to the culpability and negligence of those intrusted with its management, yet it is certain, that much is inseparable from the employment of this terrible power. How immense is the contrast in favour of Electro-Magnetism! Instead of depending on the sobriety and attention of a class of men generally intemperate, and almost always rendered so by the fatiguing and incessant labour which those employed upon steam engines are compelled to undergo, you behold in magnetism a type of that Heavenly Majesty which rules the Universe. How sublime a theme for contemplation! man, by the aid of science, compelling an omnipotent and invisible power to his service, and harnessing to his car (harmless and obedient), the power of Deity itself! Communicating to every thing connected with it a spirit of tranquillity and safety—performing all the work assigned it,

* The actual cost to run these machines is almost nominal, as the zinc is not destroyed, but merely held in solution, and can be converted into sulphate of zinc, sold to the brass founders, or restored to its original state at a cost of only fifteen per cent., proving at once its immense advantages over steam in this particular.

in silent harmony—and to the delight and astonishment of every one that beholds it for the first time.

It is impossible by the utmost vigilance to prevent accidents by steam. It is not possible, by the grossest carelessness, to cause an accident by magnetism or the means that produce it.

There cannot be a doubt that the demand for fuel to supply our innumerable steam engines has caused much misery among our population, by the enormous price to which it has enhanced that indispensable necessary of life, and there is even danger, that the supply cannot be long continued adequate to the demand, notwithstanding our immense supplies. Whilst, independently of the every day discovered stores our country (so rich in every metallic production), affords, the mines of Germany, of which zinc is a refuse, and where our staples are eagerly sought after, proffer us an exhaustless abundance, and at a cost too trivial to deserve serious notice.*

The countrymen of Franklin will not refuse the meed of praise due to the man who has followed in the path of his philosophic daring, but cheerfully award to Davenport the pre-eminence due to genius, and witness with pride another among American worthies, enrolling his name in the pages of history, as a public benefactor—for his application and improvements in this wonderful and recently discovered *Power*!

* The compiler has been recently informed, that zinc in abundance can be had in New Jersey and Vermont; and only create a demand for it, and the mines will be at once opened, and the produce of them brought to market.

PROFESSOR SILLIMAN'S REMARKS.

FROM SILLIMAN'S AMERICAN JOURNAL OF SCIENCE AND ARTS,
NO. I. VOL. XXXII. APRIL, 1837.

*Notice of the Electro-Magnetic Machine of Mr. Thomas Dav-
enport, of Brandon, near Rutland, Vermont.*

MANY years have passed since motion was first produced by galvanic power. The dry columns of De Luc and Zamboni caused the vibration of delicate pendulums and the ringing of small bells, for long periods of time, even several years, without intermission.

In 1819—20, Professor Oersted, of Copenhagen, discovered that magnetism was evolved between the poles of a galvanic battery. Professor Schweigger, of Halle, Germany, by his galvanic multiplier, succeeded in rendering the power manifest, when the galvanic battery was nothing more than two small wires, one of copper and the other of zinc, immersed in as much acidulated water as was contained in a wine-glass. The power thus evolved, was made to pass through many convolutions of insulated wire, and was thus augmented so as to deflect the magnetic needle sometimes even 90° . Professor Moll, of Utrecht, by winding insulated wire around soft iron, imparted to it prodigious magnetic power, so that a horseshoe bar, thus provided and connected with a galvanic battery, would lift over one hundred pounds. About the same time, Mr. Joseph Henry, of Albany, now Professor Henry, of Princeton College, by a new method of winding the wire, obtained an almost incredible magnetic force, lifting six or seven hundred pounds, with a pint or two of liquid, and a battery of corresponding size; nor did he desist, until a short time after, he lifted thousands of

pounds, by a battery of larger size, but still very small, (1830.) This gentleman was not slow to apply his skill to the generation of motion, and a successful attempt of his, is recorded in this journal, vol. xx. p. 340. A power was thus applied to the movement of a machine, by a beam suspended in the centre, which performed regular vibrations in the manner of a beam of a steam engine. This is the original application from which have sprung, or at least to which have succeeded, several similar attempts, both in this country and in Europe. A galvanic machine was reported to the British Association, in 1835, by Mr. McGauly, of Ireland, and he has renewed his statements of successful experiments, at the late meeting at Bristol. Mr. Sturgeon, of Woodwich, England, also reports a galvanic machine as being in use on his premises for pumping water, and for other mechanical purposes.*

But, I believe that Mr. Davenport, named at the head of this notice, has been more successful than any other person in the discovery† of a galvanic machine of great simplicity and efficiency. During the last two or three years, much has been said of this discovery in the newspapers, and it is probable that in a future number of this journal, drawings and an accurate description of the machine may be given. Having been recently invited to examine a working model, in two varieties of form, and to report the result, I shall now attempt nothing more than a general description, such as may render intelligible the account I am to give.

1. *The Rotary Machine, composed of Revolving Electro-Magnets, with Fixed Permanent Magnets.*

This machine was brought to New-Haven, March 16, 1837, by Mr. Israel Slade, of Troy, N. Y., and by him set in motion for my examination. The moving part is composed of two iron bars placed horizontally, and crossing each other at right angles. They are both five and a half inches long, and they

* Sturgeon's Annals of Electricity, Magnetism, &c., No. I. Vol. I., Oct., 1836. Mr. Sturgeon remarks, that, as he thought it might be improved, the machine has long since been laid by.—*Compiler*.

† Mr. Davenport appears to have been strictly the inventor of a method of applying galvanism to produce rotary motion.

are terminated at each end by a segment of a circle made of soft iron; these segments are each three inches long in the chord line, and their position, as they are suspended upon the ends of the iron bars, is horizontal.

This iron cross is sustained by a vertical axis, standing with its pivot in a socket, and admitting of easy rotation. The iron cross bars are wound with copper wire, covered by cotton, and are made to form, at pleasure, a proper connexion with a circular battery, made of concentric cylinders of copper and zinc, which can be immersed in a quart of acidulated water. Two semicircles of strongly magnetised steel, form an entire circle, interrupted only at the two opposite poles, and within this circle, which lies horizontally, the galvanized iron cross moves in such a manner that its iron segments revolve parallel and very near to the magnetic circle, and in the same plane. Its axis at its upper end, is fitted by a horizontal cog-wheel to another and larger vertical wheel, to whose horizontal axis weight is attached and raised by the winding of a rope. As soon as the small battery, destined to generate the power, is properly connected with the machine, and duly excited by diluted acid, the motion begins, by the horizontal movement of the iron cross, with its circular segments or flanges. By the galvanic connexion, these crosses and their connected segments are magnetised, acquiring north and south polarity at their opposite ends, and being thus subjected to the attracting and repelling force of the circular fixed magnets, a rapid horizontal movement is produced, at the rate of two hundred to three hundred revolutions in a minute, when the small battery was used, and over six hundred with a calorimotor of large size. The rope was wound up with a weight of fourteen pounds attached, and twenty-eight pounds were lifted from the floor. The movement is instantly stopped by breaking the connexion with the battery, and then reversed by simply interchanging the connexion of the wires of the battery with those of the machine, when it becomes equally rapid in the opposite direction.

The machine, as a philosophical instrument, operates with beautiful and surprising effect, and no reason can be discovered why the motion may not be indefinitely continued. It is easy

to cause a very gradual flow of the impaired or exhausted acid liquor from, and of fresh acidulated water into the receptacle of the battery ; and whenever the metal of the latter is too much corroded to be any longer efficient, another battery may be instantly substituted, and that even before the connexion of the old battery is broken. As to the energy of the power, it becomes at once a most interesting inquiry, whether it admits of indefinite increase ? To this inquiry it may be replied, that provided the magnetism of both the revolving cross and of the fixed circle can be indefinitely increased, then no reason appears why the energy of the power cannot also be indefinitely increased. Now, as magnets of the common kind, usually called permanent magnets, find their limits within, at most, the power of lifting a few hundred pounds, it is obvious that the revolving galvanic magnet must, in its efficiency, be limited, by its relation to the fixed magnet. But it is an important fact, discovered by experience, that the latter is soon impaired in its power by the influence of the revolving galvanic magnet, which is easily made to surpass it in energy, and thus, as it were, to overpower it. It is obvious, therefore, that the fixed magnet, as well as the revolving, ought to be magnetised by galvanism, and then there is every reason to believe that the relative equality of the two, and of course their relative energy, may be permanently supported, and even carried to an extent much greater than has been hitherto attained.

2. Rotating Machine, composed entirely of Electro-Magnets, both in Fixed and Revolving Members.

A machine of this construction has been this day, March 29, 1837, exhibited to me by Mr. Thomas Davenport, himself, who came from New-York to New-Haven for that purpose.

It is the same machine that has already been described, except that the exterior fixed circle is now composed entirely of electro-magnets.

The entire apparatus is therefore constructed of soft unmagnetic iron, which being properly wound with insulated copper wire, is magnetised in an instant, by the power of a very small battery.

The machine is indeed the identical one used before, except

that the exterior circle of permanent magnets is removed, and in its place is arranged a circle of soft iron, divided into two portions to form the poles.

These semicircles are made of hoop-iron, one inch in width, and one-eighth of an inch in thickness. They are wound with copper wire, insulated by cotton—covering about ten inches in length on each semicircle, and returning upon itself by a double winding, so as to form two layers of wire, making on both semicircles about one thousand and five hundred inches.

The iron was not wound over the entire length of one of the steel semicircles; but both ends were left projecting, and being turned inward, were made to conform to the bend of the other part; each end that is turned inward and not wound is about one-third of the length of the semicircle. These semicircles being thus fitted up, so as to become at pleasure, galvanic magnets, were placed in the same machine that has been already described, and occupied the same place that the permanent steel magnets did before. The conducting wires were so arranged, that the same current that charged the magnets of the motive wheel, charged the stationary ones, placed around it, only one battery being used. It should be observed, that the stationary galvanic magnets, thus substituted for the permanent steel ones, were only about half the weight of the steel magnets. This modification of the galvanic magnet is not, of course, the best form for efficiency; this was used merely to try the principle, and this construction may be superseded by a different and more efficient one. But with this arrangement, and notwithstanding the imperfection of the mechanism of the machine,—when the battery, requiring about one quart of diluted acid to immerse it, was attached,—it lifted 16lbs. very rapidly, and when the weight was removed, it performed more than 600 revolutions per minute.

So sensible was the machine to the magnetic power, that the immersion of the battery one inch into the acidulated water, was sufficient to give it rapid motion, which attained its maximum when the battery was entirely immersed. It appeared to me that the machine had more energy with the electro-magnets than with those that were permanent; for, with the small-

est battery, whose diameter was three inches and a half, its height five inches and a half, and the number of concentric cylinders, three of copper and three of zinc, the instrument manifested as great power as it had done with the largest batteries, and even with a large calorimotor, when it was used with a permanent instead of a galvanic magnet. With the small battery, and with none but electro or galvanic magnets, it revolved with so much energy as to produce a brisk breeze, and powerfully to shake a large table on which the apparatus stood.

Although the magnetization of both the stationary and revolving magnets was imparted by one and the same battery, the magnetic power was not immediately destroyed, by breaking the connexion between the battery and the stationary magnet; for, when this was done, the machine still performed its revolutions with great, although diminished energy; in practice, this might be important, as it would give time to make changes in the apparatus, without stopping the movement of the machine.

It has been stated by Dr. Ritchie, in a late number* of the London and Edinburgh Phil. Magazine, that electro-magnets do not attract at so great a distance as permanent ones, and therefore are not well adapted for producing motion. On this point, Mr. Davenport made the following experiment, of which I was not a witness, but to which I give full credit, as it was reported to me by Mr. Slade, in a letter, dated New-York, March 24, 1837.

Mr. Davenport suspended a piece of soft iron with a long piece of twine, and brought one pole of a highly charged steel magnet within the attracting distance, that is, the distance at which the iron was attracted to the magnet; by measurement, it was found that the steel magnet attracted the iron one inch and one-fourth. A galvanic magnet was next used of the same lifting power, and consequently of much less weight; the attracting distance of this magnet was found to be one inch and three-fourths, showing a material gain in favour of the galvanic magnet. Mr. Slade inquires, "has Mr. Ritchie's magnet been so

* January, 1837.

constructed as to give a favourable trial to this principle?"* Mr. Davenport informs me that each increase in the number of wires has been attended with an increase of power.

CONCLUSIONS.

1. It appears then, from the facts stated above, that electro-magnetism is quite adequate to the generation of rotary motion.

2. That it is not necessary to employ permanent magnets in any part of the construction, and that electro-magnets are far preferable, not only for the moving, but for the stationary parts of the machine.

3. That the power generated by electro-magnetism may be indefinitely prolonged, since, for exhausted acids, and corroded metals, fresh acids and batteries, kept always in readiness, may be substituted, even without stopping the movement.

4. That the power may be increased beyond any limit hitherto attained, and probably beyond any which can be with certainty assigned,—since, by increasing all the members of the apparatus, due reference being had to the relative proportionate weight, size, and form of the fixed and moveable parts—to the length of the insulated wires and the manner of winding them—and to the proper size and construction of the battery, as well as to the nature and strength of the acid or other exciting agent, and the manner of connecting the battery with the machine, it would appear certain, that the power must be increased in some ratio which experience must ascertain.

5. As electro-magnetism has been experimentally proved to be sufficient to raise and sustain several thousands of pounds, no reason can be discovered why,—when the acting surfaces are, by skilful mechanism, brought as near as possible, without contact,—the continued exertion of the power should not generate a continued rotary movement, of a degree of energy inferior indeed to that exerted in actual contact, but still nearly approximating to it.

6. As the power can be generated cheaply and certainly—

* This question I am not able to answer, as I have not seen any account of the apparatus or of the experiment, but only of the result.

as it can be continued indefinitely—as it has been very greatly increased by very simple means—as we have no knowledge of its limit, and may therefore presume on an indefinite augmentation of its energy, it is much to be desired, that the investigation should be prosecuted with zeal, *aided by correct scientific knowledge, by mechanical skill, and by ample funds.* It may therefore be reasonably hoped, that science and art, the handmaids of discovery, will both receive from this interesting research, a liberal reward.

Science has thus, most unexpectedly, placed in our hands a new power of great but unknown energy.

It does not evoke the winds from their caverns; nor give wings to water by the urgency of heat; nor drive to exhaustion the muscular power of animals; nor operate by complicated mechanism; nor accumulate hydraulic force by damming the vexed torrents; nor summon any other form of gravitating force; but, by the simplest means,—the mere contact of metallic surfaces of small extent, with feeble chemical agents, a power every where diffused through nature, but generally concealed from our senses,—is mysteriously evolved, and by circulation in insulated wires, it is still more mysteriously augmented, a thousand and a thousand fold, until it breaks forth with incredible energy; there is no appreciable interval between its first evolution and its full maturity, and the infant starts up a giant.

Nothing since the discovery of gravitation and of the structure of the celestial systems, is so wonderful as the power evolved by galvanism; whether we contemplate it in the muscular convulsions of animals, the chemical decompositions, the solar brightness of the galvanic light, the dissipating consuming heat, and more than all, in the magnetic energy, which leaves far behind all previous artificial accumulations of this power, and reveals, as there is full reason to believe, the grand secret of terrestrial magnetism itself.

B. S.

NEW-HAVEN, March 31, 1837.

MR. DAVENPORT.

It will not be uninteresting, perhaps, to those who take an interest in this newly applied power, to know something of the individual who has gone farther to perfect the principles of Electro-Magnetism, as applied to machinery, than any other man living. Mr. Davenport was, by occupation, a blacksmith, with a very limited education, but one of those natural geniuses that spring up untutored and rude, with a mind determined to persevere, when once roused to action by this all pervading and natural source of motion. It is no doubt mortifying to the scientific to find themselves distanced, as it were, by a mere practical blacksmith; but such are some of nature's freaks, and it is not the first time that true inherent genius has been able to "go ahead" of the scientific labours of the professor—if not associated with practical experience in mechanics. Mr. Thomas Davenport, who is a native of the State of Vermont, while pursuing his trade, had occasion to go to the Penfield iron works, where he first saw a galvanic battery applied to an Electro-Magnet, and was so struck with the power of this small affair, that he purchased that, instead of the iron as he had intended. On his return home with his newly acquired treasure, he confidently asserted that from the magnet and battery he could produce power amply sufficient to move the largest machinery now in use, or drive a boat across the ocean.

This assertion was of course generally ridiculed among his friends and neighbours, who, no doubt, began to think him a fit subject for a lunatic asylum. His was not the mind to be discouraged by the sneers of the ignorant or the incredulous, and he immediately relinquished his profession of a blacksmith, and devoted his time to the study of Electro-Magnetism, with an intensity of application worthy of such a cause. After several months spent in experiment, he at last succeeded in producing

his long sought wish, rotary motion; but so very feeble at that time as not to be able to convince the most sanguine of its ultimate and triumphant success. This we believe was in 1833, and from that time to the present he has been experimenting, and making one improvement after another, of sufficient magnitude to be able to convince, at this time, nine out of ten persons who have witnessed his latest triumphs, that Electro-Magnetism is destined, and at no distant day, to supersede steam for many important branches of the arts and manufactures, if not in all.

The Models of Davenport's Machines are now exhibited at the Masonic Hall, in this city; and also in New York, at No. 5 Barclay Street, where they are properly explained, and the principles illustrated by which they are put in motion. There has probably never been any thing exhibited that has given such universal satisfaction, whether to the man of science, the practical mechanic, or one totally ignorant of the subject here explained; but more than all, the ladies, who have such a dread of steam-boilers, or the sparks from a locomotive, have looked upon this invention with the most intense anxiety. The proceeds of the exhibition are devoted entirely to experimenting for the further improvement and developing the increase of greater power than that hitherto attained.

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ELECTRO-MAGNETISM.

A
BRIEF ESSAY OR INFORMAL LECTURE
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ALSO,
OTHER INTERESTING MATTER ON THIS SUBJECT.

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